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Dynamics of Catalyst Nanoparticles

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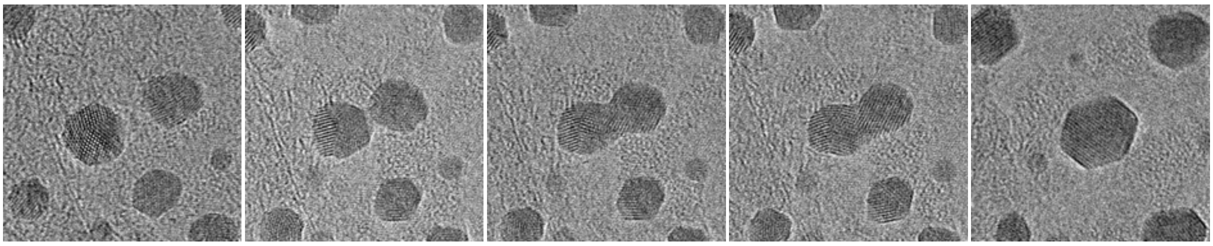
Abstract
Transmission electron microscopy (TEM) is extensively used in catalysis research. Recent developments in aberration correction allows imaging surface structures with unprecedented resolution. Using these correctors in conjunction with environmental TEM (ETEM), where imaging of materials can be done under gas exposure, dynamic phenomena such as sintering and growth can be observed with sub-Ångstrøm resolution.
Metal nanoparticles contain the active sites in heterogeneous catalysts, which are important for many industrial applications including the production of clean fuels, chemicals and pharmaceuticals, and the cleanup of exhaust from automobiles and stationary power plants. Sintering, or thermal deactivation, is an important mechanism for the loss of catalyst activity. In order to initiate a systematic study of the dynamics and sintering of nanoparticles, various catalytic systems have been studied in atmospheres relevant for their operation. By studying growth patterns, we found that changes in the atmospheres changes heavily effects not only the rate of sintering but also the mechanism through which it occurs. In many cases, anomalously large particles where observed indicating that particle sintering is not solely governed by the mechanisms previously proposed. These results are divided into the different phases of the catalyst lifetime.



ETEM image sequence of Au/graphene in 200 Pa H_2 at 104°C. The image series shows different stages of two Au particles coalescing resulting in a single Au particle. Image dimensions: 18x18 nm.